MASONRY CONSTRUCTION ELEMENT AND METHOD OF MAKING

Field of the Invention

The present invention relates in general to masonry construction, and more particularly, to pre-fabricated self-supporting masonry assemblies used to build flat, curved, or twisted constructions.

Background of the Invention

Masonry arches, vaults, domes, and other curved spanning surfaces have long been recognized for their inherent beauty. However, these structures are expensive to construct, primarily due to the labor and materials required for temporary support of their own weight and for field assembly. Thus, these masonry structures have left the main stream of modern building practice.

By way of example only, in the past, masonry structures for supporting floors, walls, or ceilings are composed of numerous individual masonry blocks. These masonry structures are typically made by building temporary scaffolding or shoring on which the masonry blocks are individually placed with mortar in the spaces between the blocks. Once the mortar has cured and the masonry structures are sufficiently stabilized, the temporary support structures can be removed. Because the support structures have to be built by hand and the blocks have to be placed and handled by hand, the cost of building these structures is excessive. Additionally, because some of these masonry structures rely on forces being distributed across an arch, certain thickness of building materials are imposed on the structure, thereby

limiting the design flexibility and increasing the cost of the structure.

An example in the prior art of a typical shoring system is found in United States Patent number 5,444,948, by Trapp, and entitled: "ADJUSTABLE ARCH SUPPORT". Trapp shows an adjustable arch support for use in brick and other masonry construction. The support uses a plurality of adjustable fingers with supports or shoes being attached thereto. Although reusable, this support is complex and adds to the overall cost of the masonry structure. The support needs to be custom fitted for each arch that is to be built. Thus, the Trapp method does not solve labor intensity or the overall cost.

Another example of the prior art is found in United States patent number 4,704,754 by Bonasso, and entitled: "TENSION ARCH STRUCTURE", showing a structural system used in bridges, buildings, and other structures. Generally, the structural system uses cables that are stretched and anchored between end supports so that lateral compressive elements can be placed over the cables. Alternatively, the structural system can use a combination of hollow compression tube with cables. Bonasso's masonry elements are not all identical, and must accommodate a cable whose position varies with respect to the surfaces of the masonry elements. These cables must be in place and anchored to an abutment prior to placement of the masonry (or concrete) elements, thus limiting opportunities to pre-fabricate the entire assembly. Further, the abutments must resist the tensile forces of the cables that support the masonry elements, thus adding to the complexity of the abutment. Once again, Bonasso does not solve the problem of being able to make spanning masonry structures in a cost effective manner.

United States Patent number 5,060,426, by Jantzen, entitled: "BUILDING STRUCTURE", shows a building structure fabricated with prefabricated interlocking

metal voussoir units placed onto a prefabricated metal structure. The metal structure is made of prefabricated connecting devices that provide a skeleton for the voussoir units to be placed onto. Once again the building structure, as well as the metal structure is deficient in its ability to provide a cost effective and ease of use solution to erecting curved masonry spanning assemblies.

None of the above methods or techniques has adequately solved the labor intensity or cost of making curved masonry spanning assemblies, but they have instead increased the complexity of making such assemblies.

Accordingly, a versatile, self-supporting masonry construction element that is easy to manufacture, use, and adapt to field conditions is desired, so that curved masonry supporting structures such as arches, vaults, and domes can be built economically.

Summary of the Invention

The above problems and others are at least partially solved and the above purposes and others are realized in a masonry construction element including a flexible element having a first surface and a block element with the block element attached to the first surface of the flexible element. More particularly, the attachment of the block element to the flexible element is accomplished either mechanically, chemically, or a combination of both.

Also disclosed is a beam element including a flexible element having a first surface, a first block, and a second block. The first and second blocks are attached to the first surface of the flexible element. The beam element can have a space between the first and second block.

Additionally, a method for making and use of the beam element is disclosed. The beam elements can be used

singly or arranged next to each other to make courses of beam elements that together form curved surfaces.

It is a purpose of the present invention to provide a masonry construction element that is easy to pre-fabricate.

Another purpose of the present invention is to provide a cost effective method for making a self-supporting, adjustable, masonry construction element.

Yet another purpose of the present invention is to provide a cost effective method for making a masonry beam.

Another purpose of the present invention is to provide a means to construct arches, vaults, domes, and other curved masonry structures, from self-supporting beam elements.

Brief Description of the Drawings

FIG. 1 illustrates a simplified perspective view of masonry construction element during manufacture of a beam;

FIG. 2 illustrates a simplified wall structure having beams stacked on top of each other;

FIG. 3 illustrates a simplified sectional view of a curved masonry beam;

FIG. 4 illustrates a simplified partial view of a plurality of masonry beams;

FIG. 5 illustrates a simplified partially completed masonry ceiling;

FIG. 6 illustrates a simplified masonry arch fabricated with a masonry beam; and

FIG. 7 illustrates another simplified masonry arch fabricated with a masonry arch with a curved, cantilevered, masonry beam.

Detailed Description of the Drawings

Referring to FIG. 1, a beam element 10 under partial manufacture is shown including construction elements 12 and 14. Beam element 10 includes flexible element 16 having surfaces 18 and 20, adhesive material 22 and blocks 24, 26, 28, 30, 32, 52, 54, 56, 58, and 60. Elements being the same or similar will retain their original identification numerals. It should be understood that Figs. 1-7 are illustrations and that actual dimensions and size relationships are not necessarily drawn to scale. While blocks 24-32 and 52-60 are sometimes discussed together in the interest of clarity, it should be understood that blocks 24-32 can have different physical properties and uses then blocks 52-60.

Flexible element 16 is made of any suitable flexible material. For example, a plastic material, which includes but is not limited to, nylons, rayons, polyesters, fiberglass, polypropylenes, or the like, can be used. Additionally, several other materials can be used such as carbon fiber materials, composite materials, metal mesh or the like. By way of example only, various plastic materials can be combined together with other materials to optimize strength and surface chemistry of flexible element 16. Typically, flexible element 16 is a made from a woven material. The woven material can be made to any suitable shape, but in a preferred embodiment, the woven material is flat so that a greater surface area is provided for attachment and stabilization of blocks 24-30 and 52-60 to surface 18 or surface 20 of flexible element 16. Additionally, it should be understood, while width 62 is shown to be across width of blocks 24-30 and 52-60, other widths either wider or narrower can be used. By way of example arrows 64 indicate a narrower with that could be used.

Blocks 24-30 and 52-60 can be made of any suitable material such as stone, brick, concrete, wood, or the like. As shown in Fig. 1, blocks 24 and 26 have openings 34, while blocks 28 and 30 do not. Openings 34 can be used to decrease weight when necessary facilitate adjustment, as shown by arrow 72, or the like. Additionally, openings 34 can also serve as decorative openings.

Surfaces 18 and 20 of flexible element 16 are used to bond or attach blocks 24-30 and 52-60 to surface 18 or 20. Any suitable attachment method or technique can be used for attaching or bonding blocks 24-30 and 52-60 to flexible element 16. For example, blocks 24-30 or 52-60 can be bolted, pinned, or the like so that flexible element 16 is firmly held to blocks 24-30 or 52-60. In yet another example, blocks 24-30 and 52-60 are adhered to flexible element 16. Any suitable adherent or adhesive, such as epoxies, acrylics, urethanes, or the like can be used to firmly hold blocks 24-30 and 52-60 to flexible element 16. It should be noted that for each material system different adhesives maybe used to optimize the adhesion and strength between blocks 24-30 and 52-60 to flexible element 16. Additionally, different attaching methods and/or adhesive materials can be used in combination.

By way of example only, with blocks 24-30 being made of masonry materials and flexible element 16 being made of nylon material, a methacrylate or epoxy adhesive is used to adhere blocks 24-30 to flexible element 16.

Flexible element 16 can either be adhered or attached to blocks 24-32 or 52-60, or to both. Additionally, in one embodiment of the present invention, it should be understood that blocks 52-60 are directly adhered or attached to blocks 24-32, provided that a chain of attachment exists between the upper blocks, lower blocks, and the flexible material. Additionally, it

should be understood that the size relationship between blocks 52-60 and blocks 24-32 does not need to be uniform in width, thickness, or length.

Blocks 24-32 and 52-60 can be attached to flexible element 16 such that blocks 24-30 and 52-60 are abutted against each other. However, in a preferred embodiment of the present invention, spaces 36, 41, 43, and 45 are formed. Spaces 36, 41, 43 and 45 can be any suitable distance depending upon the material system. However, spaces 36, 41, 43, and 45 can range from 0.3 centimeter (cm) to 6.0 centimeters (cm), with a typical range being between 1.0 cm to 3.0 cm, and a preferred range from 0.5 cm to 1.5cm.

As shown in Fig. 1, spacers 40 and 42 are shown at two different stages of fabrication of masonry beam element 10. Spacers 40 and 42 are made of any suitable material and in any suitable shape. For example, spacers 40 and 42 can be made of either organic materials such as plastics, wood, or inorganic materials such as metal or the like. While spacers 40 and 42 are shown having a taper, it should be understood that spacers 40 and 42 can be made in any suitable shape such as rectangular, tapered, a combination of rectangular and tapered, or the like such that spaces 41, 43, and 45 are at least partially filled with spacers 40 and 42.

Spacer 40 is positioned above space 41 between blocks 26 and 28. Spacer 42 is securely placed in space 43 between block 28 and 30. With a spacer (not shown) securely placed in space 36, another spacer (not shown) securely placed in space 45, and with spacers 40 and 42 securely placed in spaces 41 and 43, masonry beam element 10 becomes rigid in a longitudinal direction, illustrated by an arrow 70. With all the spacer properly positioned, masonry element 10 can be picked up by ends 74 and 76 and moved into place. In this configuration, masonry element 10 acts as a composite beam, tensile stresses resisted by

flexible material 16, compressive stresses resisted by the blocks 24-32 and spacers, as illustrated by spacer 42, and shear stresses resisted by flexible element 16, the means of attachment of flexible element 16, by friction between the blocks 24-32 and spacers, illustrated by spacers 40 and 42, and by any filler that may be placed into spaces 36, 41, 43, and 45. However, while masonry beam element 10 is reasonably rigidly fixed in the longitudinal direction, blocks 24-32 can be axially twisted, illustrated by an arrow 72. Thus, allowing blocks 24-32 to be individually adjusted to suit the application.

It should be understood that mortar, filler, or adhesive material of any suitable kind can be placed in spaces, illustrated by spaces 36-45 either prior to, during, or after the positioning of wedges, illustrated by 40 and 42, thereby combining an adjustment process and curing process.

Surface 20 of flexible element 16 can be used to bond or attach blocks 52, 54, 56, and 58. Any suitable attachment method or technique can be used for attaching blocks 52, 54, 56, and 58 such as bolting, pinning or using a chemical adhesive. Typically, an adhesive layer 22 is used to attach blocks 52, 54, 56, and 58 to flexible element 16. By way of example, with blocks 24, 26, 28, and 30 being substantial blocks, blocks 52, 54, 56, and 58 are veneer or decorative blocks. It should be noted that different attaching methods and adhesive materials are dependent upon the material system.

Beam element 10 is made by supporting beam element 10 by any suitable method, such as laying out blocks 24-32 or blocks 52-60 on the ground, a supporting table, or the like and attaching blocks 24-32 or 52-60 to flexible member 16. Additionally, beam 10 can be made to any desirable length, then cut into shorter lengths, thus enabling many beams to be fabricated at once to improve

efficiency, productivity, and thereby lowering cost. Moreover, by mass producing supporting beam 10, the total time spent on a job constructing and fabricating structures is further decreased, thereby substantially lowering the cost.

Referring now to Fig. 2, a wall structure 100 is shown under partial fabrication having courses 102 and 104 with beam 101 being positioned for placement on course 104. Beam 101 is shown with spacers 108, as described in Fig. 1, being securely positioned between blocks 110, thereby making beam 101 rigid and capable of being moved by ends 112. Typically, wall structure 100 is made by prefabricating a plurality of beams, one of which is illustrated by beam 101, then stacking these to form a wall of linear or curved courses. The plurality of beams is set in succession on top of each other until the desired height is reached.

Stacking and securing beams 101, 102, and 104 can be achieved by any suitable means such as using mortar, cement, or an adhesive. It should be understood that once the wall structure 100 is made and suitably cured, application of any suitable treatment, such as stucco, veneers, or the like can be done. Thus, walls, fences and other similar structures can be made in a cost effective manner. Additionally, since the blocks 110 are affixed to each other, wall structure 100 is much stronger and more durable.

Referring to Fig. 3, a simplified side view of a curved beam 302 having flexible element 16, blocks 24-32, and adhesive material 20 in various stages of fabrication. Also, a form 306 is shown having curve 308 being defined by curved element 310 with curved element being held by legs 312 with cross-members 314.

Form 306 is made by any suitable manner or technique. Form 306 and curved element 310 can be made of any suitable material such as metal, wood, plastic, or

the like. Typically, curved element 310 is used to describe curve 308. Curve 308 can be any desirable camber, or segment, or arc of any suitable function such as a circle, ellipse, oval, parabola, catenary, or the like. Once curve 308 has been defined by curved element 310, flexible beam assembly 302 is laid out on curved element 310. Blocks 24-32 are attached to flexible element 16 by any suitable means as described in Fig. 1, either prior to placement on curve 310 or after placement. Then, wedges, as illustrated by wedges 40 and 42, are placed in spaces 36, 41, 43, and 45. By positioning the wedges into spaces 36, 41, 43, and 45, the curved beam 302 is made rigid and retains curve 308. Thus, curved beam 302 can then be lifted by ends 74 and 76 and hoisted to a desirable location. Alternatively, flexible element 16 can be extended beyond the end of curved beam 302 and used to lift the beam. It should be understood that Fig. 3 is a side view and that form 306 can be constructed such that form 306 can extend into and out of the drawing, thereby allow many curved beams, illustrated by curved beam 302, to be formed. By making many curved beams, illustrated by curved beam 302, at a position that is easily accessible and convenient, orders of efficiency are gained.

Referring to Fig. 4, a simplified partial view of a plurality of curved masonry beams, illustrated by curved beams 402 and 404 positioned on supports 430 and 432. Curved beams 402 and 404 are made of blocks 406-414, blocks 420-426, and blocks 450-458 respectively, positioned on supports 430 and 432. Curved masonry beams 402 and 404 are made as previously described in Fig. 1 and 3.

Blocks 406-414 are shown attached to flexible element 434. It should be understood that blocks 420-426 are attached to another flexible element that is not visible. It should also be understood that blocks 406-

414, 420-426, and 450-458, can be made of any suitable material and in any combination. Wedges 436 are set and positioned in spaces 438 between blocks 406-414 and 420-426. With wedges 436 in position, curved masonry beams 402 and 406 can be lifted and moved into position on supports 430 and 432. Once curved beam 402 is properly positioned on supports 430 and 432, blocks 406-414 can be rotationally adjusted, or twisted, as shown by arrow 442, to accommodate supports that are not at the same inclination.

The spaces between blocks 406-414 can then be filled with any suitable filling material as previously discussed. Subsequently, curved beam 404 can be positioned on supports 430 and 432 and the processes repeated. It should be noted that this is just one of several methods or techniques for using a plurality of curved masonry beams. For example, a plurality of curved masonry beams are made at one time, individual curved beams of the plurality are then positioned and adjusted on supports 430 and 432. Spaces between the plurality of blocks are then filled with any suitable filling material.

Generally and by way of example, assuming a uniformly distributed load along beam 402, maximum shear stress occurs at supports 430 and 432. Shear stress is resisted between blocks 406-414, by flexible element 434, and by friction forces at wedges 436. A vertical shear resisting force is developed at the interface between blocks 406-414 and wedges 436 described by the following equation:

$$F_v = \mu_s N$$

where F_v is the shear force developed by friction, μ_s is a coefficient of static friction, and N is the normal compressive force between the blocks 406-414 and wedges 436. N results from bending moment and from compression

of the space between bocks 406-414 by movement of the flexible element to accommodate shear stress. Driving wedges 436 between blocks 406-414 before setting beam 402 in place, beam 402 is stiffened and a compressive pre-stress is established that generates friction to resist vertical shear. Thus, beam 402 can be raised into position. Horizontal shear stress between blocks 406-414 are resisted by flexible element 434. Maximum moment occurs at block 410. Moment is resisted between blocks 406-414 by tension at flexible element 434 and by compression at wedges 436. Additional resistance would also be added by any suitable filler. The distribution of compressive stress at wedges 436 is a function of the modular ratio, i.e., the ratio of the modulus of elasticity of the wedge material to the modulus of elasticity of the flexible element. Additionally, tensile stress along beam 402 is resisted by the flexible element.

Referring now to Fig. 5, a simplified supporting structure 500 is shown having supports 530 and 532 in partial fabrication of a ceiling 506. Ceiling 506 is made by successively placing a plurality of curved beams 502 onto supports 530 and 532.

Attaching the plurality of curved beams, illustrated by curved beam 504, can be accomplished by any suitable method or technique such as nailing, pinning, adhering or the like. However, it should be realized that the plurality of curved beams are self-supporting between supports 530 and 532.

Additionally, it should be understood that several advantages are realized by the present invention. For example, curved beam 504 can be made much thinner then the prior art. Thus, curved beam 504 weighs less and uses less material, thereby reducing cost and increasing the ease of manufacture. It is believed that this advantage is gained because curved beam 504 does not

necessarily rely on the classic understanding of arch theory. Another advantage in the present invention can be realized by integrating both the classical manufacture of arches and the manufacture of the present invention.

Making the plurality of curved beams 502 in long strips, enables curved beams 504 to be cut at any desired length. Thus, enabling the plurality of beams to be mass produced and subsequently fabricated. By mass producing and fabricating the plurality of beams 502, cost savings are realized.

Referring now to Fig. 6, a simplified side view of a masonry arch 600 is shown being partially fabricated with a flexible beam 602 having blocks 615 being attached thereto. Supports 604 are made by any suitable method or technique to carry the loads imposed by flexible beam 602 and arch 600. While supports 604 are shown as walls in Fig. 6, it should be understood that supports 604 are made of any suitable structure such as an abutment, wall, or the like. Additionally, while Fig. 6 illustrates an arch 600, it should be understood that in certain applications of the present invention a partial arch is used. Beam 602 may comprise a portion of the whole arch 600, particularly that portion for which the voussoirs cannot support themselves during construction of the arch.

Flexible beam 602 is made as described previously in Fig. 3; however, in this particular embodiment the curve 608 describes a semicircle. It should be understood that flexible beam 602 can be made to describe any portion, line segment, or the like of curve 608, thereby producing any desired curve. As shown in Fig. 6, flexible beam 602 has spaces 614 with wedges or shims 616 being positioned in spaces 614. Also, a keystone 620 can be used as a center stone to form arch 600. However, it should be

understood that a continuation of blocks 615 can also be done.

Once supports 604 and flexible beam 602 are fabricated, and any desired beginning voussoirs are placed on supports 604, flexible beam 602 is then moved into position by any suitable method or technique such as by hand, a power device such as a crane, a hoist, or the like. Flexible beam 602 is lifted at ends 610, illustrated by arrows 612 and secured by any suitable method or technique such as cementing, bolting, pinning, adhering, or the like. After flexible beam 602 is attached or affixed to supports 604, a skin or decorative material can be applied to achieve any desired aesthetic appearance. It should be realized that by using the present invention arches such as arch 600 can be employed in architecture in a cost effective way.

Referring now to Fig. 7, a simplified side view of a masonry arch 700 is shown being partially fabricated with a flexible beam 702 having blocks 715 being attached thereto. Supports 604 may be made by any suitable method or technique to carry the loads imposed by beam 702 and arch 700.

Flexible beam 702 is made of similar materials as described in Fig. 1 and curve 708 is similar to that described in Fig. 6. However, in this particular embodiment, flexible element 16 is positioned on the extrados surface of arch 700.

As shown in Fig. 7, flexible beam 702 has spaces 714 with spacer 716 being positioned in spaces 714. Also, a keystone 720 can be used as a center stone to form arch 700. However, it should be understood that a continuation of blocks 715 can also be done.
Once supports 604 and flexible beam 702 are fabricated, flexible beam 702 is moved into position by any suitable

method or technique such as by hand, a power device such as a crane, a hoist, or the like. In this specific embodiment of the present invention, flexible beam 702 is lifted in the middle, indicated by arrow 710, and secured by any suitable method or technique such as cementing, bolting, pinning, adhering, or the like. After flexible beam 702 is attached or affixed to supports 604, a skin or decorative material can be applied to achieve any desired esthetic appearance. It should be realized that by using the present invention, arches such as arch 700 can be employed in architecture in a cost effective way.

While we have shown and described specific embodiments of the present invention, further modifications and improvements will occur to those skilled in the art. We desire it to be understood, therefore, that this invention is not limited to the particular forms shown and we intend in the appended claims to cover all modification that do not depart from the spirit and scope of the invention.

By now, it should be appreciated that a novel construction element, method of making, and method of use, have been described. The construction element incorporates a flexible material having blocks attached thereto, thereby providing simpler methods of constructing curved masonry structures or of walls.